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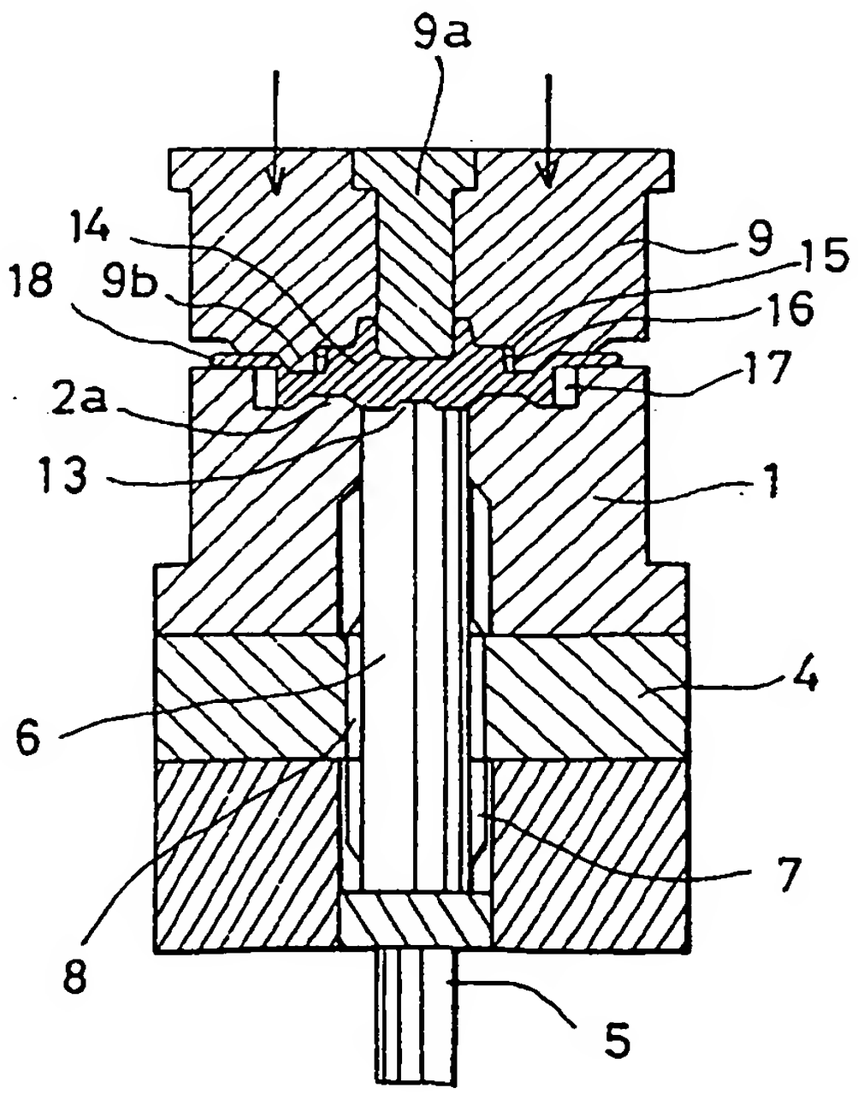
(54) Device for and method of forging a helical gear.

(57) The present invention provides an improved device for and a novel method of forging a helical gear with a sufficiently high accuracy and smoothly removing the helical gear from a die without giving any damage. An ejector (6) of the device has a guide element (4) which allows a screw-type movement, that is, simultaneous movement along and rotation around a vertical axis of the ejector (6). The ratio of a rotational angle to a moving distance along the vertical axis in a work (14) with a plurality of helical teeth is identical with the same in the ejector (6). While the ejector (6) moves along the vertical axis by a predetermined distance and simultaneously rotates by a predetermined angle. the work (14) moves along the vertical axis by the same distance and rotates by the same angle. This makes the helical teeth on the work (14) free from an excessive external pressure and allows smooth removal of the work from the cavity (2) of the die (1).

FIG. 2



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The present invention relates to a device for forging a helical gear and also to a novel method of forging the same.

In a conventional plastics working process for forging a helical gear, a forged work is guided and rotated by a plurality of helical-tooth forging elements formed on a fixed die to be taken out of the die. In an alternative process, a die is rotated for removal of a fixed work.

In the former method, the tooth profile of the helical teeth may be damaged on the removal of the work. In the latter method, on the other hand, a rotational mechanism of the die may not appreciably absorb an excessive stress. Moreover, a small clearance naturally formed in the rotational mechanism decreases the accuracy of the die.

One object of the invention is thus to provide an improved device for forging a helical gear.

Another object of the invention is to provide a forging device which allows a helical geared work to be taken out of a die without any damage.

A further object of the invention is to provide an improved method of forging a helical gear and removing the same from a die.

The above and other related objects are realized by a device for forging a helical gear and removing the forged helical gear from a die according to the claims. The device may include a die having a cavity of a predetermined shape and a plurality of helical-tooth forging elements formed on an inner circumferential face of the cavity for forming a plurality of helical teeth on a side wall of a work, an ejector guide integrally formed with or securely fixed to the die, an ejector supported by the ejector guide to be rotatable around a central axis of the ejector and movable along the central axis between a first position and a second position, a knock-out pin movable along the central axis for moving the ejector between the first position and the second position, a punch for pressing the work to form the helical teeth on the work, and a joint element formed on the ejector for securely joining the work with the ejector to allow an integral movement and rotation of the work with the ejector.

The ejector is located below the cavity of the die at the first position and is protruded through a center of the cavity upon a press-up movement of the knock-out pin at the second position.

The ejector has a first guiding element while the ejector guide has a second guiding element corresponding to and engaging with the first guiding element. The first guiding element has a plurality of first guiding helical teeth, and the second guiding element has a plurality of second guiding helical teeth mating with the first guiding helical teeth. For example, one of the first guiding element and the second guiding element is formed as a male-type screw member while the other of the first guiding element and the second guiding element is constituted as a female-type screw member. The ejector is thus rotatably and movably fitted in the ejector guide through an engagement of the first guiding element with the second guiding element.

When the knock-out pin is pressed upward along the central axis, the ejector is rotated and moved upward simultaneously through an engagement of the first guiding element and the second guiding element. The press-up movement of the knockout pin also moves up and rotates the work, which is securely joined with the ejector via the joint element and has the plurality of helical teeth formed thereon. The work moves upward and rotates synchronously with movement and rotation of the ejector wherein the helical teeth formed on the work engage with the helical-tooth forging elements disposed on the cavity of the die.

The ratio of a rotational angle to a moving distance along the central axis in the work is identical with the same in the ejector. When the knock-out pin is pressed upward, the ejector moves along the central axis from the first position to the second position by a predetermined distance and simultaneously rotates by a predetermined angle. Meanwhile, the work with the plurality of helical teeth moves along the central axis by the same distance and rotates by the same angle. This makes the helical teeth on the work free from an excessive force and allows smooth removal of the work from the cavity of the die.

The invention also provides a novel method of forging a helical gear and removing the forged helical gear from a die. The method includes the steps of

A. setting a work into a cavity of a die and on an ejector via a joint element for securely joining the work with the ejector,

the cavity having a predetermined shape, the die having a plurality of helical-tooth forging elements formed on an inner circumference of the cavity for forming a plurality of helical teeth on a side wall of the work, the ejector being supported by an ejector guide securely fixed to or integrally formed with the die to be rotatable around a central axis of the ejector and movable the central axis between a first position where the ejector is located below the cavity of the die and a second position where the ejector is protruded through a center of the cavity,

wherein the ejector has a first guiding element and the ejector guide has a second guiding element corresponding to and engaging with the first guiding element, whereby the ejector being movably and rotatably fitted in the ejector guide through an engagement of the first guiding element with the second guiding element,

B. descending and pressing down a punch onto the work to form the plurality of helical teeth on the side wall of the work,

C. lifting up the punch and moving the ejector

along the central axis from the first position to the second position simultaneously with a rotation relative to the ejector guide, and

D. removing the work from the cavity of the die wherein the work being securely joined with the ejector via the joint element and moved out of the die upon a movement of the ejector to the second position.

One of the first guiding element of the ejector and the second guiding element of the ejector guide may be formed as a male-type screw member while the other of the first guiding element and the second guiding element is constituted as a female-type screw member, thus allowing a screw-type movement of the ejector, that is, simultaneous movement along and rotation around the central axis.

The screw-type movement of the ejector synchronously moves up and rotates the work wherein the helical teeth formed on the work engage with the helical-tooth forging elements disposed on the cavity of the die. The ratio of a rotational angle to a moving distance along the central axis in the work is identical with the same in the ejector. While the ejector moves along the central axis from the first position to the second position by a predetermined distance and simultaneously rotates by a predetermined angle. The work with the plurality of helical teeth moves along the central axis by the same distance and rotates by the same angle. This makes the helical teeth on the work free from an excessive external pressure and allows smooth removal of the work from the cavity of the die.

These and other objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of the exemplary preferred embodiment with reference to the accompanying drawings of which

Fig. 1 is a cross sectional view showing a first step of forging a helical gear with a helical gear-forging device according to the invention;

Fig. 2 is a cross sectional view showing a second step of forging the helical gear; and

Fig. 3 is a cross sectional view showing a third step of forging the helical gear.

A device for and a method of forging a helical gear according to the invention are described in detail based on the drawings. Figs. 1 through 3 show a process of forging a helical gear with a helical gear-forging device of the invention.

A die 1 includes a cavity 2 formed on a top face thereof and having a predetermined shape corresponding to a helical gear portion of a final product. The cavity 2 has a first ring projection 2a on a bottom face thereof. The die 1 further includes a plurality of helical-tooth forging elements 3 formed on an inner circumferential face of the cavity 2 for forming helical teeth on a side wall of a work 14. An ejector guide 4 for supporting an ejector 6 penetrating a center of the cavity 2 is fixed to and disposed below the die 1. The ejector 6 has a joint projection 13 of a polygonal shape on a top end face thereof.

The ejector 6 supported by the ejector guide 4 is movable along a vertical axis thereof between a first position and a second position corresponding to a vertical movement of a knock-out pin 5. The ejector 6 is located below the cavity 2 of the die 1 at the first position shown in Fig. 1 and is protruded through the center of the cavity 2 upon a press-up movement of the knock-out pin 5 at the second position shown in Fig. 3.

The ejector 6 has a plurality of (preferably three or more) first guiding helical teeth 7 while the ejector guide 4 has a plurality of (preferably three or more) second guiding helical teeth 8 corresponding to and engaging with the first guiding helical teeth 7. The movable ejector 6 is thus fitted in and supported by the fixed ejector guide 4 through engagement of the first guiding helical teeth 7 with the second guiding helical teeth 8. For example, the first guiding helical teeth 7 are formed as a male-type screw member and the second guiding helical teeth 8 are as a female-type screw member. Alternatively, the first guiding helical teeth 7 and the second guiding helical teeth 8 may be formed as a female-type screw and a male-type screw, respectively.

When the knock-out pin 5 is pressed upward along the vertical axis, the ejector 6 is rotated and moved upward simultaneously through the screw type engagement of the first guiding helical teeth 7 and the second guiding helical teeth 8. The press-up movement of the knock-out pin 5 also rotates and moves up the work 14 having a plurality of helical teeth 17 formed thereon by the plurality of helical-tooth forging elements 3 on the cavity 2 of the die 1. The work 14 moves upward and rotates synchronously with movement and rotation of the ejector 6 wherein the helical teeth 17 formed on the work 14 engage with the helical-tooth forging elements 3 disposed on the cavity 2 of the die 1.

The ratio of a rotational angle to a moving distance along the vertical axis in the work 14 is identical with the same in the ejector 6. When the knock-out pin 5 is pressed upward, the ejector 6 moves along the vertical axis from the first position to the second position by a predetermined distance and simultaneously rotates by a predetermined angle. Meanwhile, the work 14 with the plurality of helical teeth 17 moves along the vertical axis by the same distance and rotates by the same angle. This allows smooth removal of the work 14 from the cavity 2 of the die 1.

A punch 9 disposed above and coaxially with the cavity 2 of the die 1 has a two-stepped recess 10 consisting of a larger-diametral step and a smaller-diametral step as shown in Fig. 1. The larger-diametral step is provided with a plurality of straight-tooth forging elements 11 on the circumference thereof for forming

a dog gear on the work 14. Each of the straight-tooth forging elements 11 has a chamfering portion 12. The punch 9 also has an inner punch 9a which is fitted in a center of the punch 9 and protruded into the two-stepped recess 10. The punch 9 is further provided with a second ring projection 9b on a bottom face thereof.

A process of forging a helical gear with the device thus constructed is described hereinafter.

After the work 14 is set in the cavity 2 of the die 1, the punch 9 is descended and pressed down onto the work 14 as shown by the arrow of Fig. 1. A certain pressure applied onto the work 14 via the punch 9, in cooperation with the inner punch 9a and the first and the second ring projections 2a and 9b protruded into the work 14, allows a plurality of straight teeth 16 with guide chamfers 15 and a plurality of helical teeth 17 to be formed on the circumference of the work 14 as shown in Fig. 2. An excessive portion of the work 14 radially runs to a clearance between the die 1 and the punch 9 to form a fin 18.

The knock-out pin 5 is then pressed upward along the vertical axis while the punch 9 is lifted up as shown in Fig. 3. A press-up movement of the knock-out pin 5 rotates and simultaneously moves up the ejector 6 as described above. The work 14 rotates and moves up together with the ejector 6 to be separated and removed from the cavity 2 of the die 1. The work 14 is securely coupled and joined with the ejector 6 via the polygonal joint projection 13 formed on the top end face of the ejector 6.

The screw-type movement of the ejector 6 corresponds to a screw-type movement of the helical teeth 17 on the work 14 with respect to the helical-tooth forging elements 3 as described above. This makes the helical teeth 17 on the work 14 free from any excessive pressure during removal of the work 14 from the cavity 2. The helical teeth 17 formed in the above manner have a sufficient accuracy and precision.

In a subsequent post-working process, the fin 18 is removed from the work 14, a through hole for a shaft is formed on the center of the work 14, and the guide chamfers 15 of the straight teeth 16 are inversely tapered.

There may be many modifications, alternations, and changes without departing from the scope or spirit of essential characteristics of the invention, and thereby it is clearly understood that the above embodiment is only illustrative and not restrictive in any sense.

For example, the straight-tooth forging elements 11 of the punch 9 may be omitted according to the requirement. The polygonal joint projection 13 used as the joint element may be replaced by an eccentrically projected pin or an eccentrically formed recess. The first and the second ring projections 2a and 9b arranged for making a final product thin and light in weight may also be omitted according to the requirement.

Claims

1. A device for forging a helical gear and removing said forged helical gear from a die, said device comprising

   a die having a cavity of a predetermined shape and a plurality of helical-tooth forging elements formed on an inner circumferential face of said cavity for forming a plurality of helical teeth on a side wall of a work,

   an ejector guide integrally formed with or securely fixed to said die,

   an ejector supported by said ejector guide to be rotatable around a central axis of said ejector and movable along said central axis between a first position where said ejector is located below said cavity of said die and a second position where said ejector is protruded through a center of said cavity, and

   joint means formed on said ejector for securely joining said work with said ejector to allow an integral movement and rotation of said work with said ejector,

   wherein said ejector has first guiding means and said ejector guide has second guiding means corresponding to and engaging with said first guiding means, whereby said ejector being movably and rotatably fitted in said ejector guide through an engagement of said first guiding means with said second guiding means.

2. A device in accordance with claim 1, wherein said first guiding means has a plurality of first guiding helical teeth, and said second guiding means has a plurality of second guiding helical teeth mating with said plurality of first guiding helical teeth.

3. A device in accordance with claim 1, wherein one of said first guiding means and said second guiding means is formed as a male-type screw element while the other of said first guiding means and said second guiding means is formed as a female-type screw element; and, optionally

   I) wherein a rotation and vertical movement of said ejector through an engagement of said male-type screw element with said female-type screw element synchronously rotates and moves said work securely joined with said ejector by said joint means, said work moving and rotating through an engagement of said plurality of helical teeth formed on the side wall of said work with said plurality of helical-tooth forging elements disposed on said cavity of said die; in which case, further optionally,

II) wherein said
ejector rotates by a first angle simultaneously with moving along said central axis by a first distance while said work rotates by a second angle simultaneously with moving along said central axis by a second distance, a first ratio of said first angle to said first distance is identical with a second ratio of said second angle to said second distance; in which case either
III) said first angle may be equal to said second angle, or
IV) said device
further comprising a knock-out pin movable along said central axis for moving said ejector between said first position and said second position, and a punch for pressing said work to form said plurality of helical teeth on the side wall of said work, in which latter case, optionally, either
V) said punch
has a smaller-diametral first recess and a larger-diametral second recess arranged coaxially with and adjacent to said smaller-diametral first recess, said larger-diametral second recess having a plurality of straight-tooth forging elements for forming a plurality of straight teeth coaxially with said plurality of helical teeth on the side wall of said work; or
VI) wherein said
cavity of said die has a first ring projection for forming a first ring groove on one side of said work, and said punch has a second ring projection for forming a second ring groove on the other side of said work.

4. A method of forging a helical gear and removing said forged helical gear from a die, said method comprising the steps of

A. setting a work into a cavity of a die and on an ejector via joint means for securely joining said work with said ejector,

said cavity having a predetermined shape, said die having a plurality of helical-tooth forging elements formed on an inner circumference of said cavity for forming a plurality of helical teeth on a side wall of said work, said ejector being supported by an ejector guide securely fixed to or integrally formed with said die to be rotatable around a central axis of said ejector and movable said central axis between a first position where said ejector is located below said cavity of said die and a second position where said ejector is protruded through a center of said cavity,

wherein said ejector has first guiding means and said ejector guide has second guiding means corresponding to and engaging with said first guiding means, whereby said ejector being movably and rotatably fitted in said ejector guide through an engagement of said first guiding means with said second guiding means,

B. descending and pressing down a punch onto said work to form said plurality of helical teeth on the side wall of said work,

C. lifting up said punch and moving said ejector along said central axis from said first position to said second position simultaneously with a rotation thereof relative to said ejector guide, and

D. removing said work from said cavity of said die wherein said work being securely joined with said ejector via said joint means and moved out of said die upon a movement of said ejector to said second position.

5. A method in accordance with claim 4, wherein in said step A, said first guiding means has a plurality of first guiding helical teeth, and said second guiding means has a plurality of second guiding helical teeth mating with said plurality of first guiding helical teeth.

6. A method in accordance with claim 4, wherein in said step A, one of said first guiding means and said second guiding means is formed as a male-type screw element while the other of said first guiding means and said second guiding means is formed as a female-type screw element.

7. A method in accordance with claim 6, wherein in said step C, a rotation and vertical movement of said ejector through an engagement of said male-type screw element with said female-type screw element synchronously rotates and moves said work securely joined with said ejector by said joint means, said work moving and rotating through an engagement of said plurality of helical teeth formed on the side wall of said work with said plurality of helical-tooth forging elements disposed on said cavity of said die.

8. A method in accordance with claim 7, wherein in said step C, said ejector rotates by a first angle simultaneously with moving along said central axis by a first distance while said work rotates by a second angle simultaneously with moving along said central axis by a second distance, a first ratio of said first angle to said first distance is identical with a second ratio of said second angle to said second distance.

9. A method in accordance with claim 8, wherein said first angle is equal to said second angle.

FIG. 1

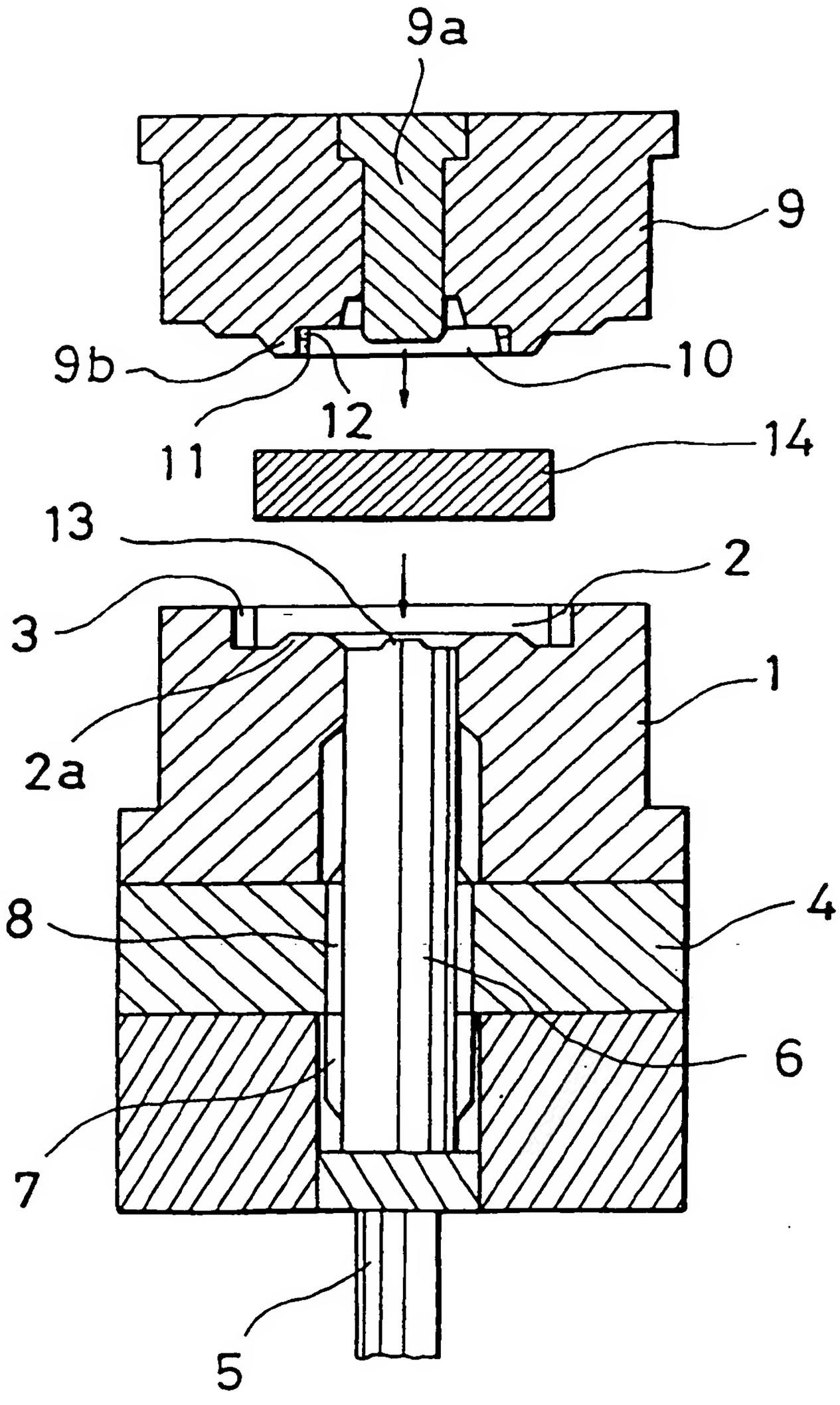


FIG. 2

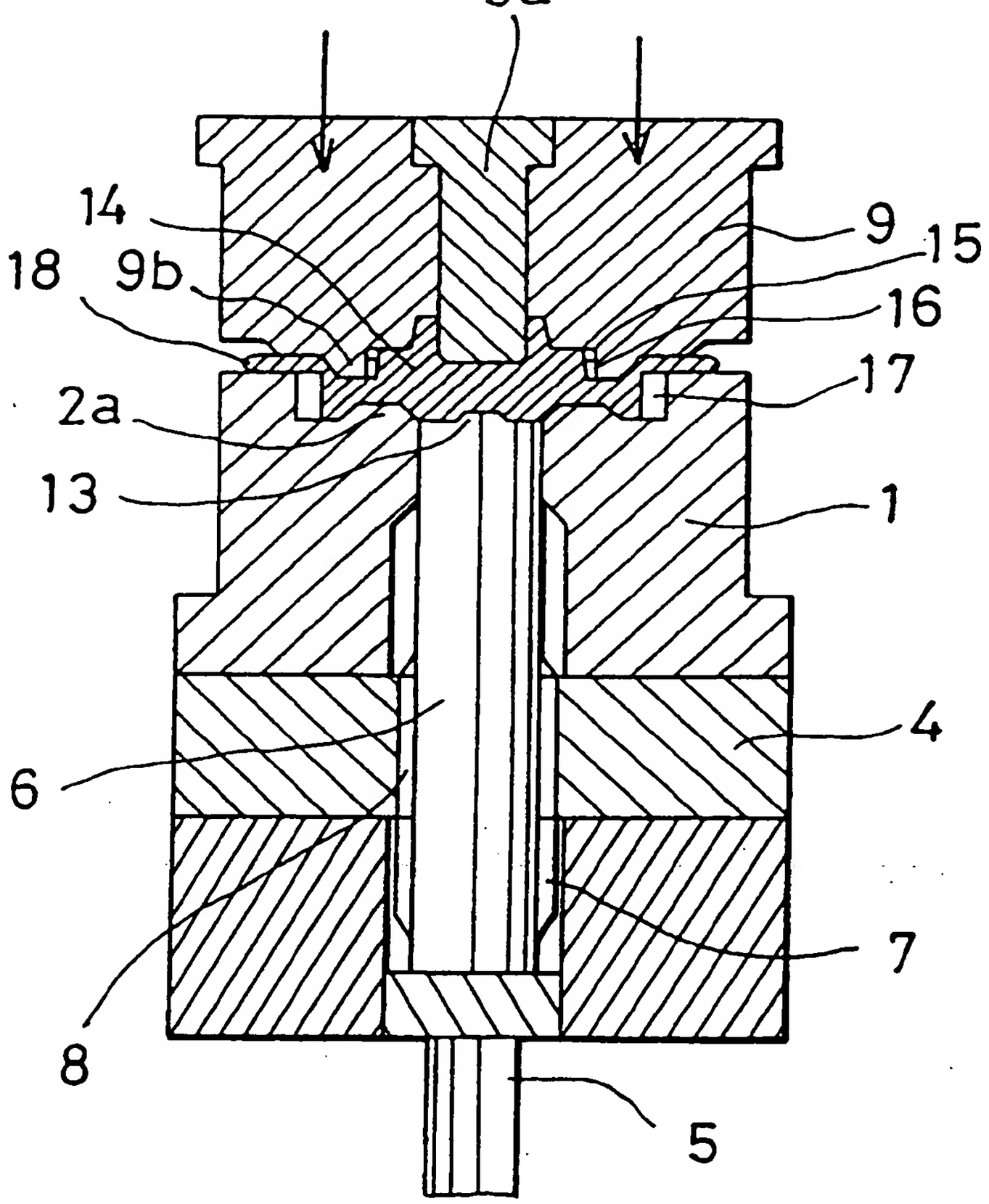
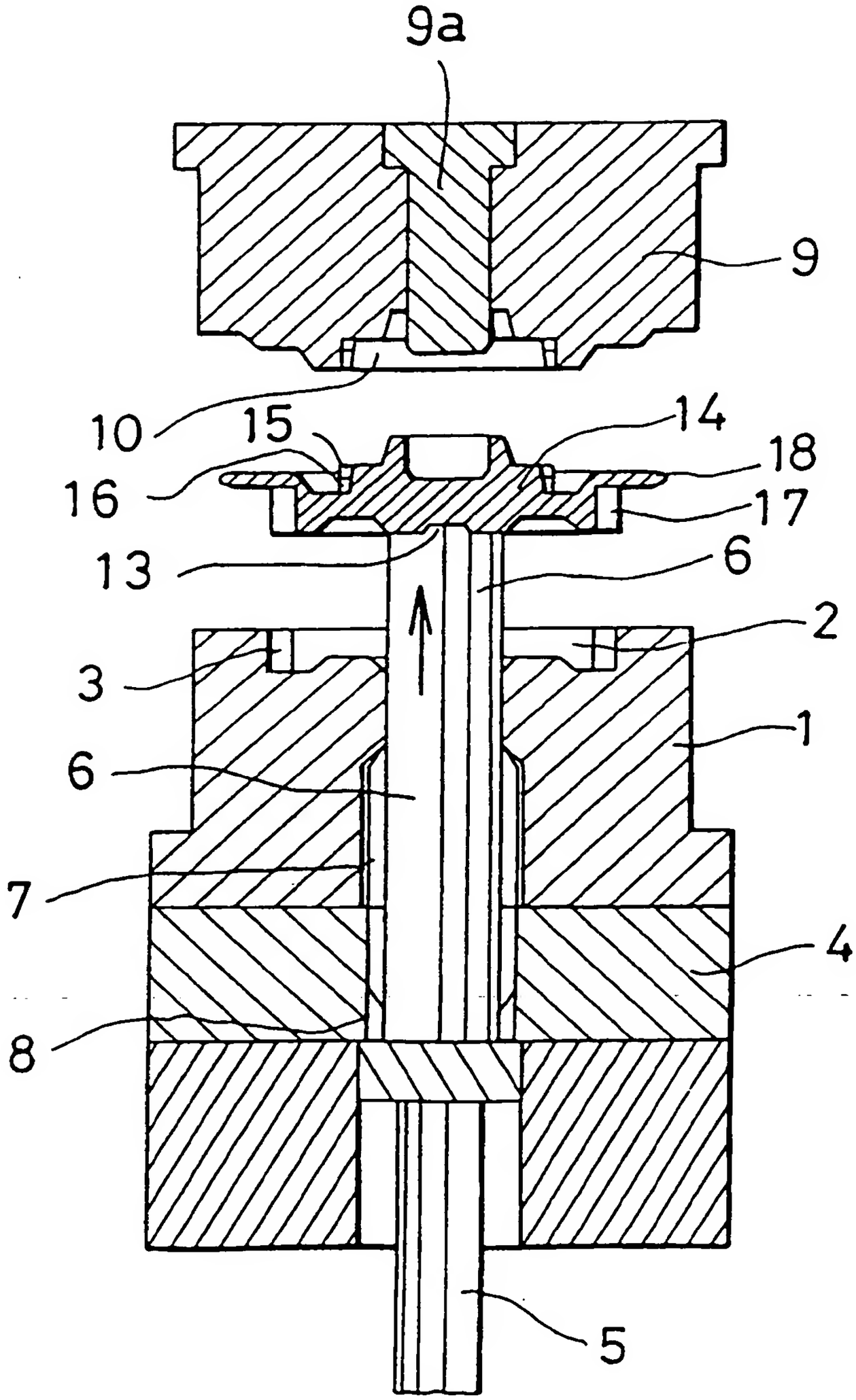


FIG.3



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 5485

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X Y A	FR-A-2 275 261 (BAYERISCHES LEICHTMETALLWERK GRAF BLUCHER VO WAHLSTATT KG) * claim 1; figures * ---	1,4,6-9 3 2,5	B21K1/30
Y	FR-A-2 626 643 (OHOKA FORGE CO. LTD) * claim 1; figures * ---	3	
A	PATENT ABSTRACTS OF JAPAN vol. 2, no. 31 7 August 1963 & JP-A-38 014 014 (SHIMANO) 3 August 1963 * abstract * ---		
A	US-A-2 674 924 (NIELSEN) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B21K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 November 1993	BARROW, J

CATEGORY OF CITED DOCUMENTS

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